Communications and Protocols

Active Networks and Active Object Storage

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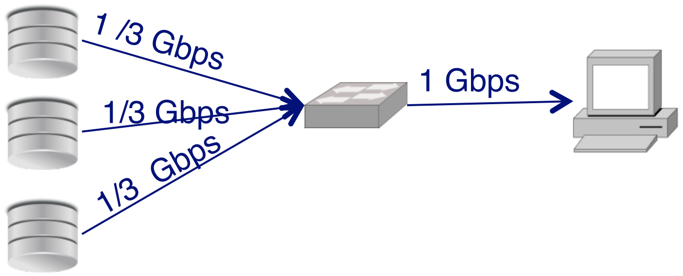
Active Storage Networks

- Active Disks
  - Intelligence at the disk can distribute computation to parallel disks
  - Process data in streams
  - Disks only have local view of data
- Active Storage Network
  - Network has a global view of data
  - Distributed caching of file system metadata and data
  - Redundancy optimizations

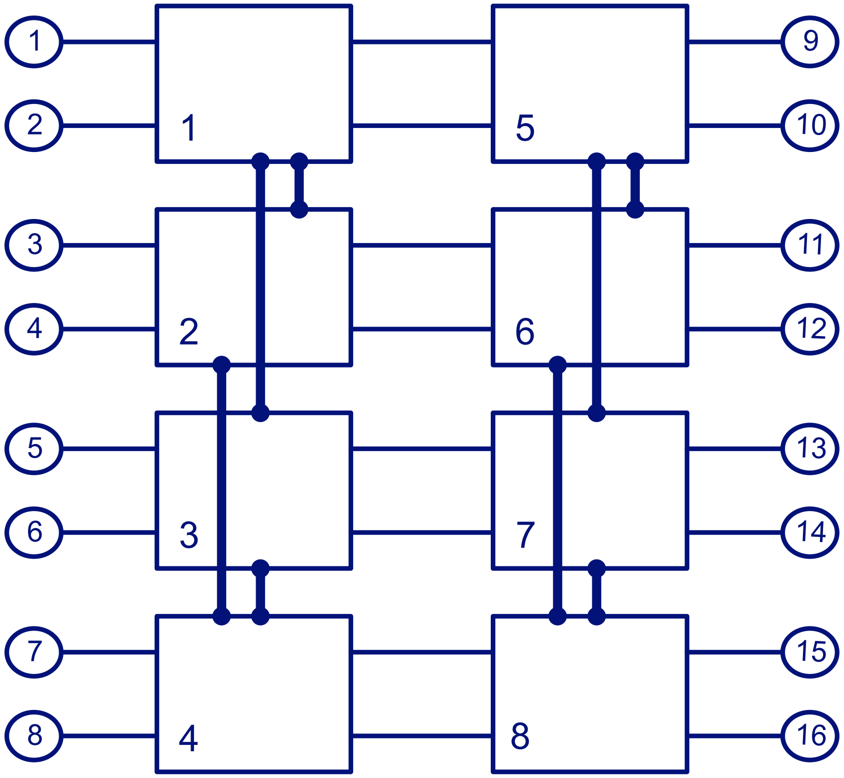
Active storage networks



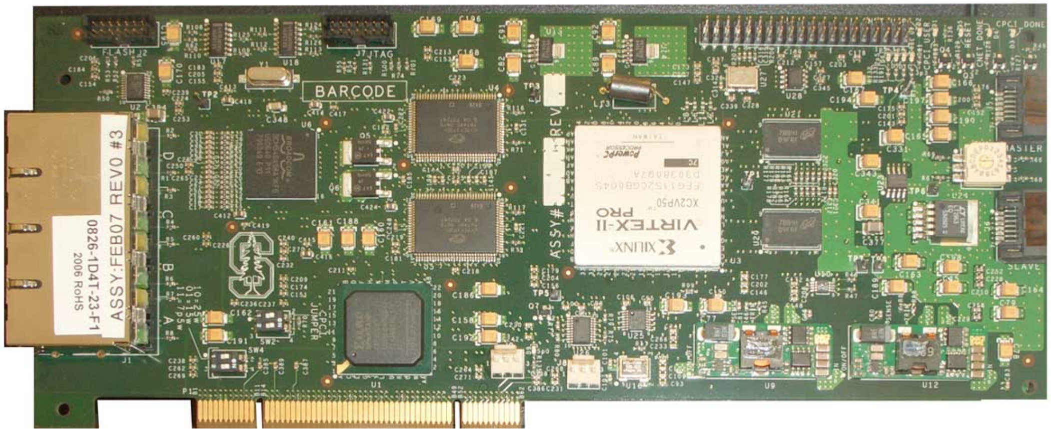
- An ASN is comprised of a smart switch along with intelligence embedded in the I/O network.
- Network Switches have global view of the data and can perform in-stream data reduction and transformation operations.
- ASN can enhance storage node performance as well as improve the computational performance of the parallel I/O systems.

Network switch topology

- 2-dilated flattened butterfly



Hardware Implementation



- NetFPGA board from Stanford
- 4 GigE connects
- 2 SATA connectors for node to node communication
- PCI bus for node to node communication

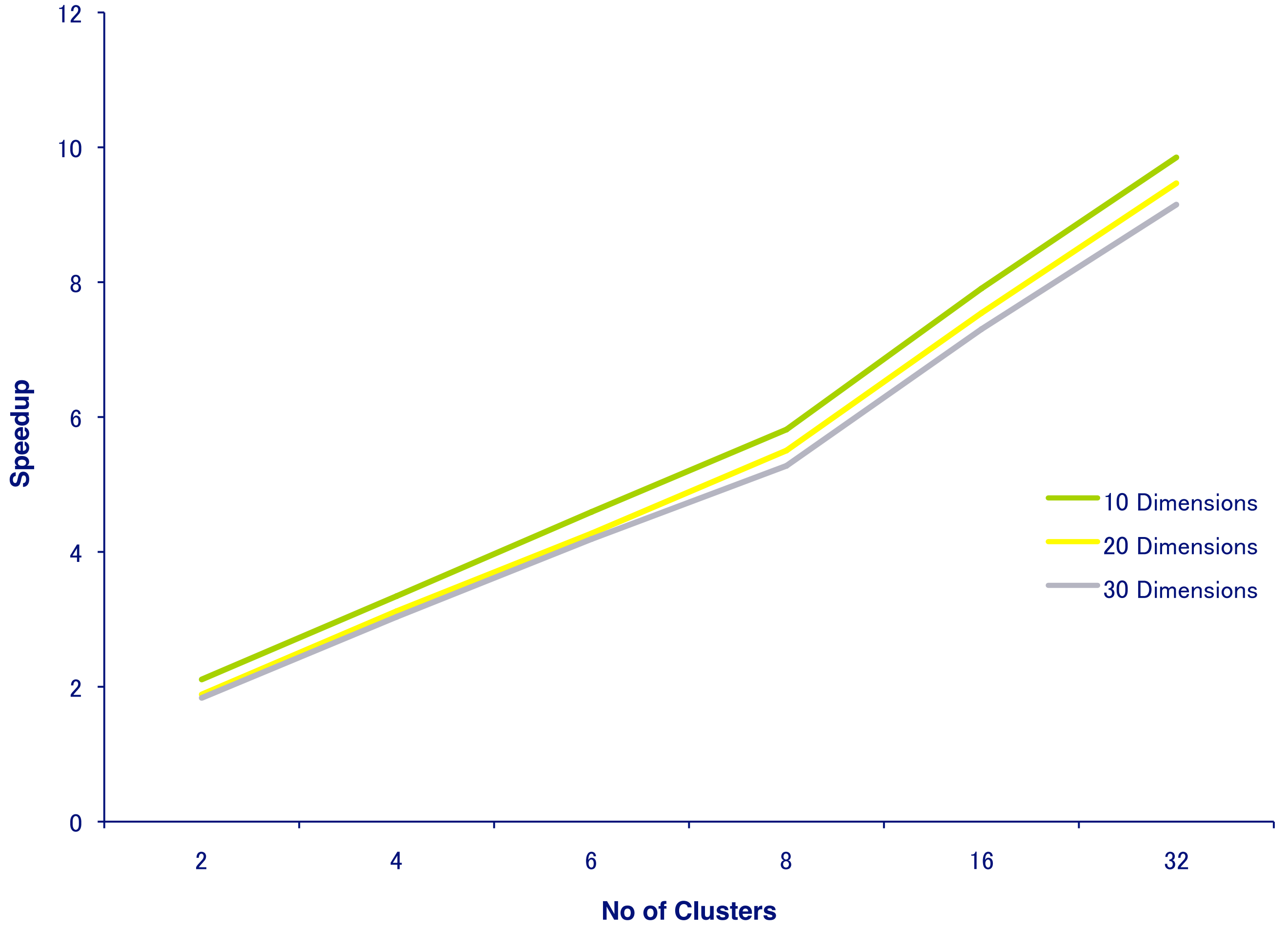
Active Storage Networks

- Application operations
  - – Reduction operations - min/max, k-means clustering, search
  - – Transformational operations – streaming, sort,
- File System Operations
  - – Locking
  - – Redundancy optimizations

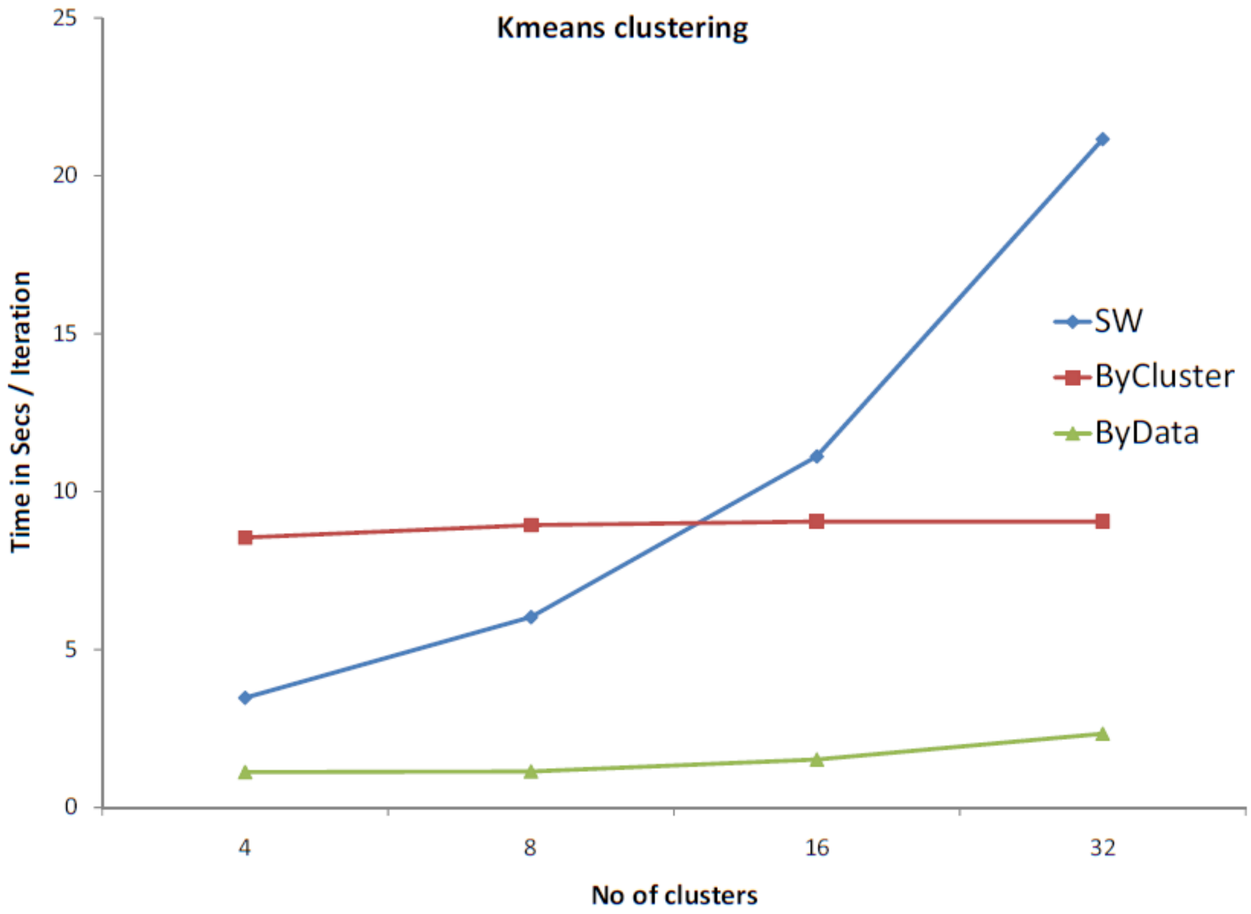
Parallelization techniques

- Functional units are re-used on reaching the reconfigurable hardware area limits.
- Data level parallelism by distributing the data to several functional units in several switch elements.
- Functional level parallelism by distributing functions to several elements.

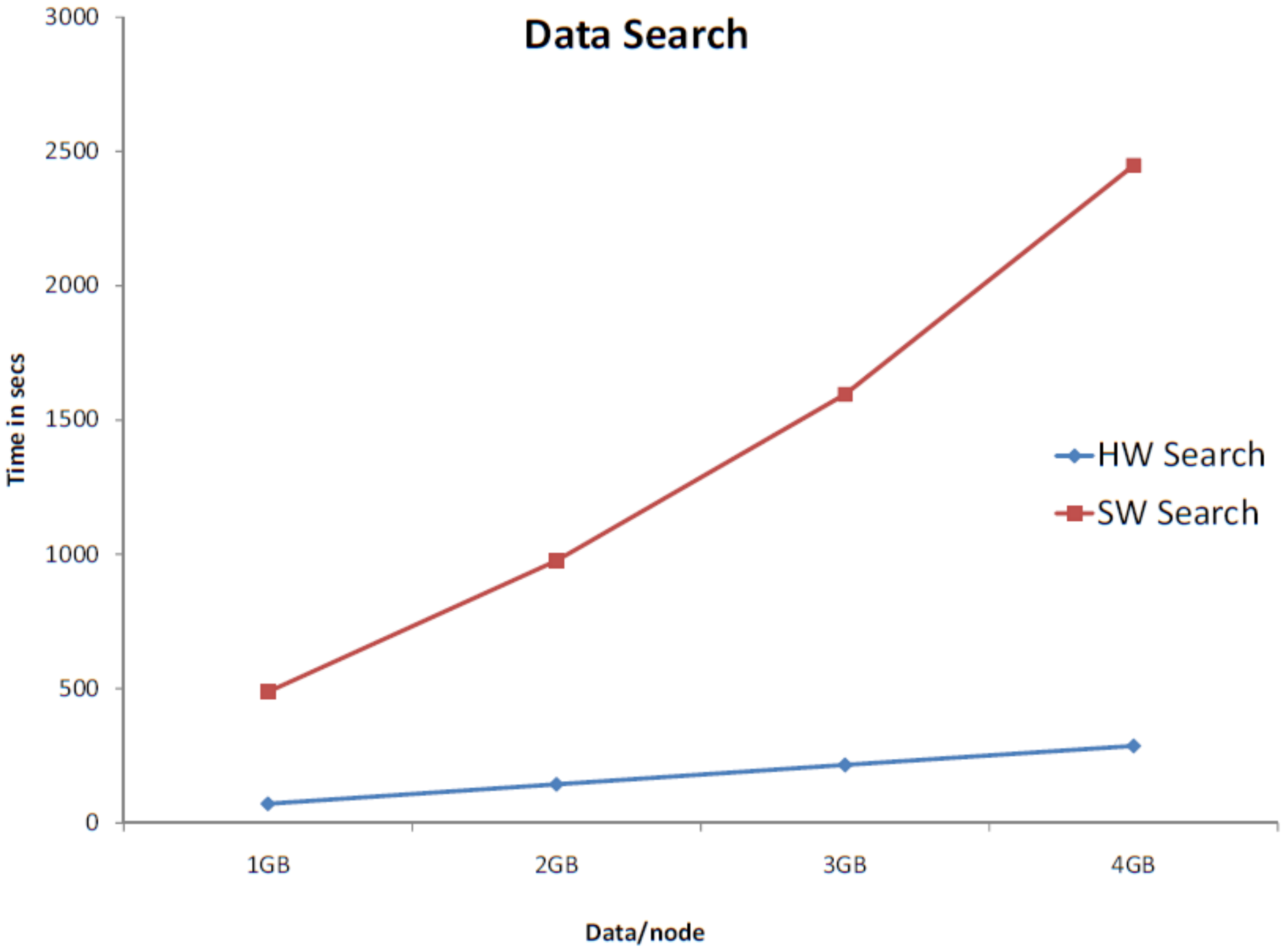
K-means clustering



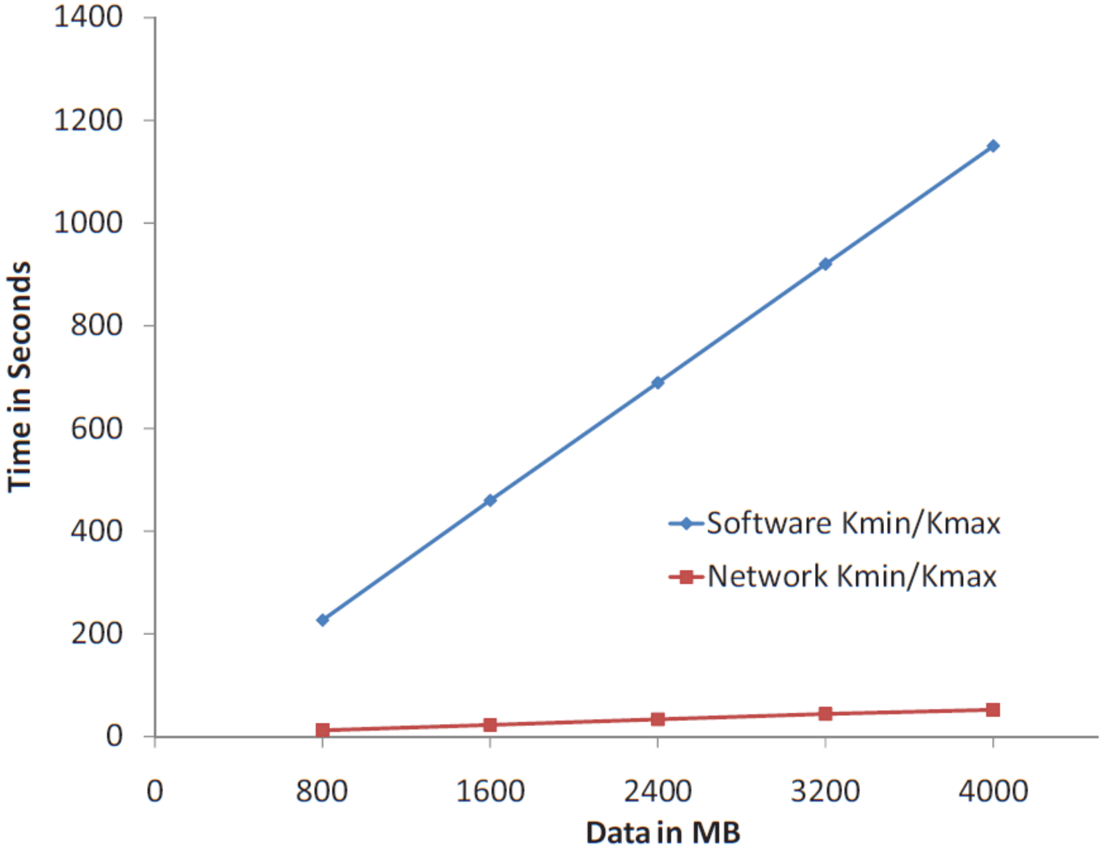
Runtime per iteration



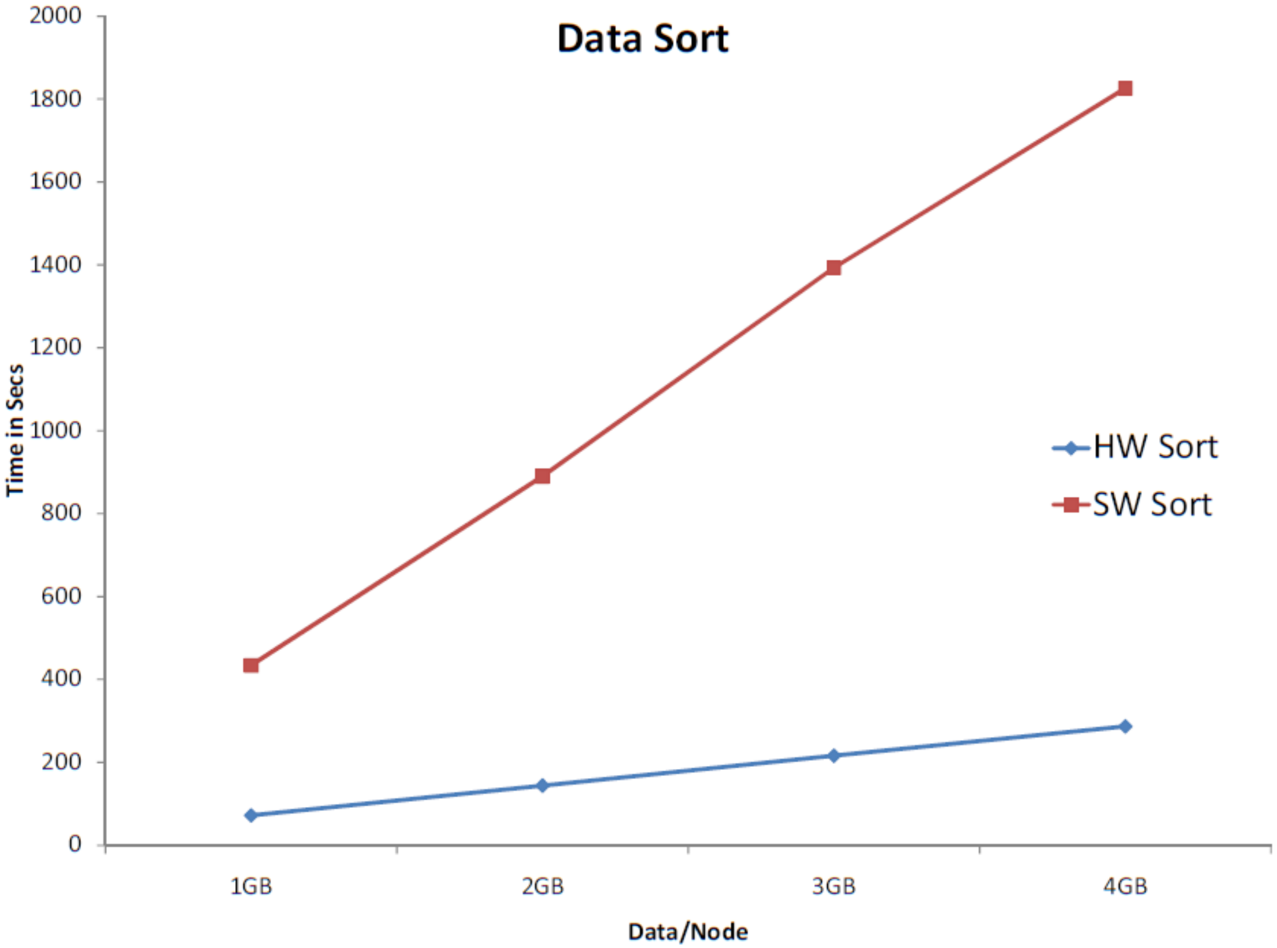
Data search


Data Search
Time in secs
3000
2500
2000
1500
1000
500
0
1GB
2GB
3GB
4GB
Data/node
HW Search
SW Search

Kmin/Kmax

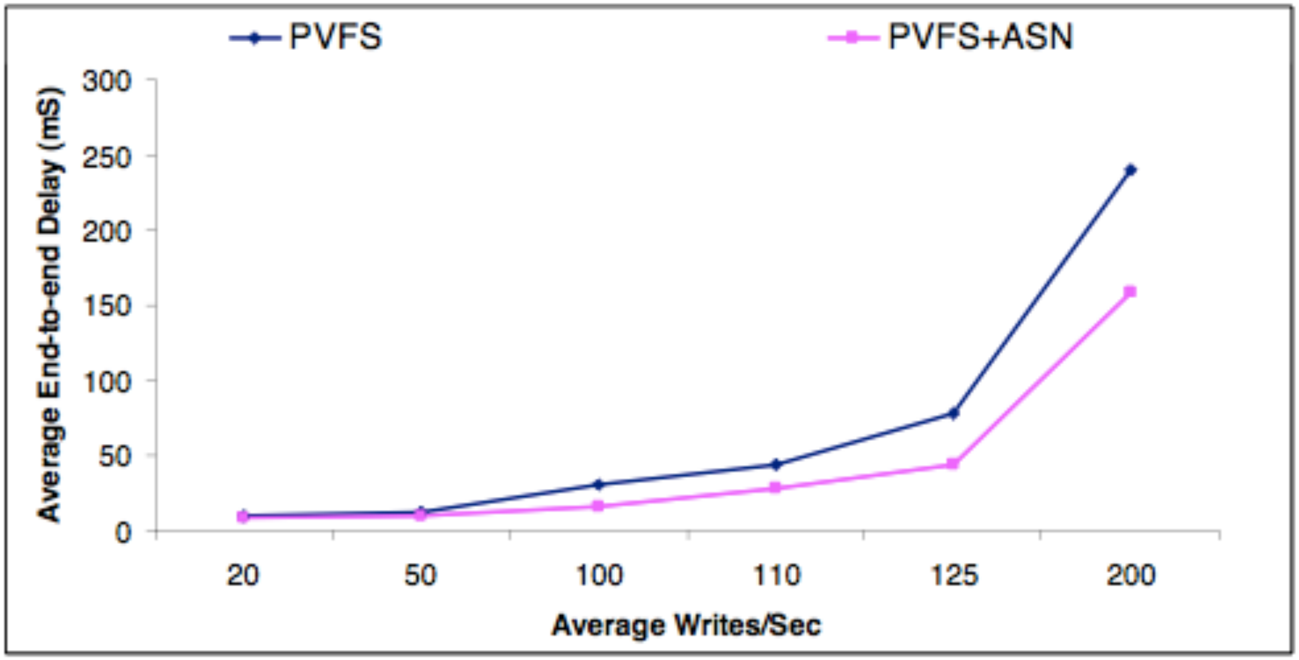

1400
1200
1000
800
600
400
200
0
Time in Seconds
0
800
1600
2400
3200
4000
Data in MB
Software Kmin/Kmax
Network Kmin/Kmax

Data sort


Data Sort
Time in Secs
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1GB
2GB
3GB
4GB
Data/Node
HW Sort
SW Sort

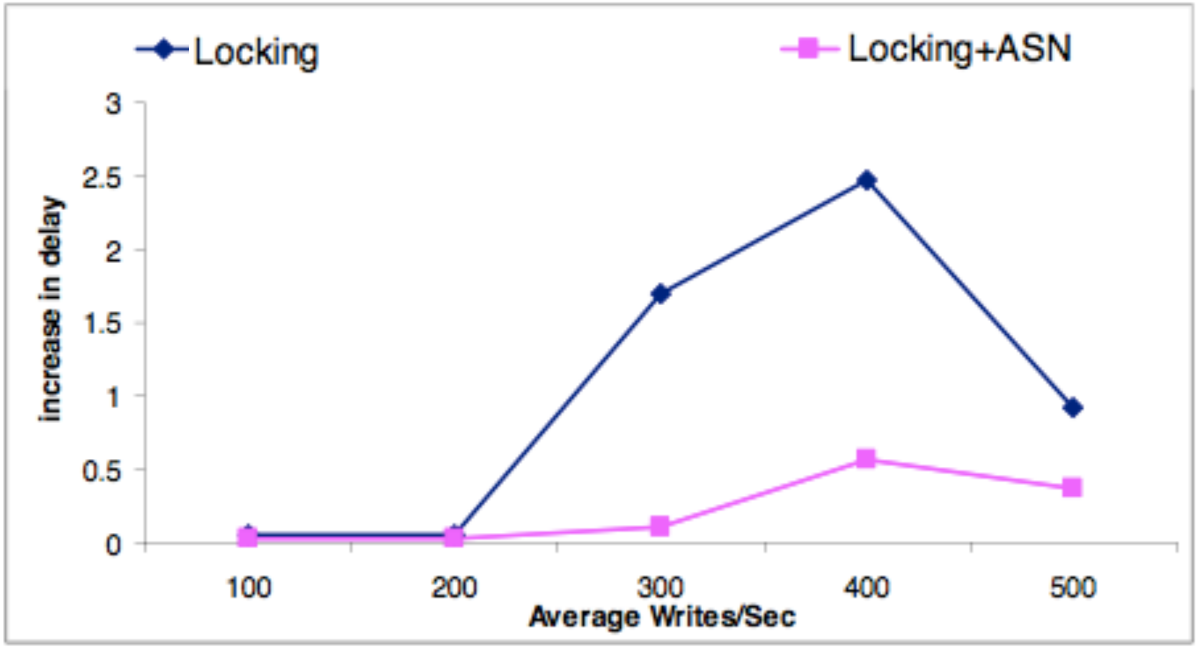
Redundancy optimizations

- RAIDed files, parity calculated in switch



File locking

- Lock table in switch



Active Storage Networks

- Lessons Learned
  - Hardware design is hard
  - HW Libraries can help
  - ASNs make most sense for reductions
  - Storage systems optimizations show promise
- What needs to get done
  - Better HW design
  - Application and FS hooks
  - When to do ASN and when to do SW?

Active Object Storage

- Active Disks
  - Intelligence at the disk can distribute computation to parallel disks
- Active Object Storage for Parallel File Systems
  - Active Disks for OSDs
  - Use Active Storage to improve parallel file system performance
  - Use Active Storage to improve parallel file system reliability
  - Application aware storage and autonomic storage using active OSDs.

Active Disks

- Can we use OSDs to make Active Disks a reality?
  - – Application-aware storage
    - Object attributes can give hints to the disk
    - Application specific
  - – Parallel File Systems
    - Felix et al. added a filtering layer to Lustre to provide active processing
  - – T10 OSD?

Active Disks using OSD

- Previous Implementation
  - – Based on disc-osd
  - – Object-oriented (Java)
    - Attach object types to storage objects
    - Define methods for object types
- New Implementation
  - – Based on osc-osd (supported by Panasas)
  - – RPC - Call functions on OSD remotely
  - – Execute Engines – C, Java, Python, etc.

Active Disks using OSD

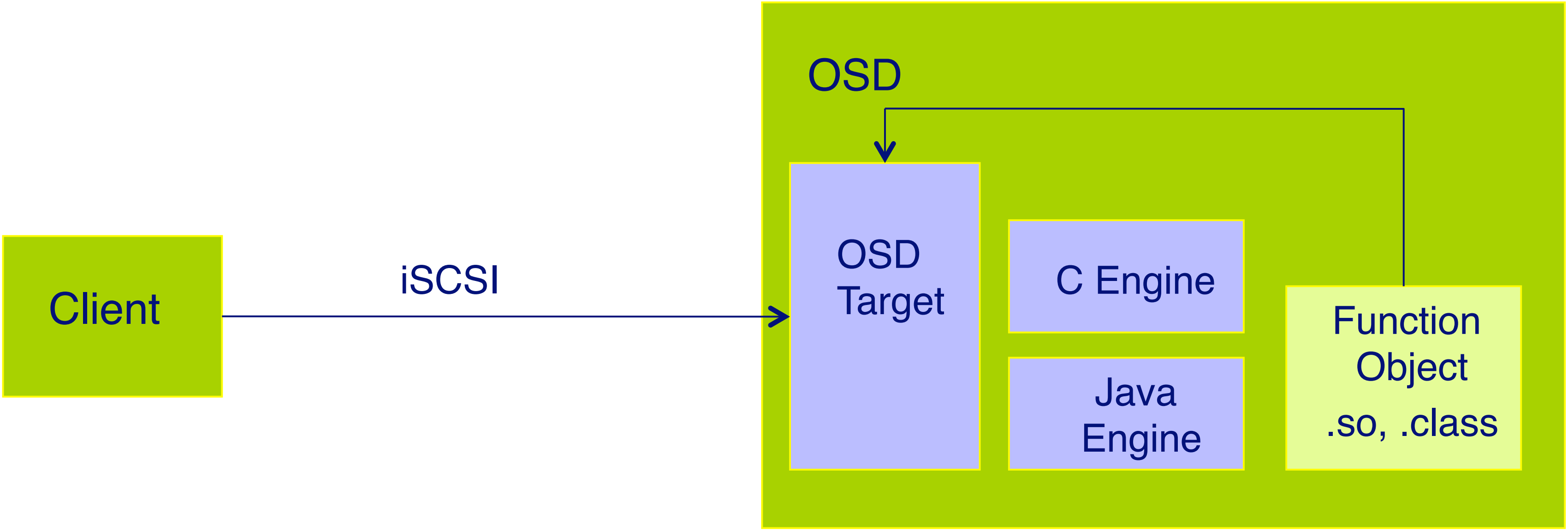
- How do you move code from client to target within OSD framework?
  - Create an object with the code
  - Each function object has a special attribute that defines the type of associated execute engine
  - OSD can support multiple execute engines

Active Disks using OSD

- How do you execute the method remotely within the OSD framework?
  - New EXECUTE FUNCTION command so that we can invoke a function
  - We use the CDB continuation to specify the parameters
  - Results (if any) returned directly or written to a new object

From T10/08-185r5 changes to OSD-2

Active Disks using OSD



Active Disks using OSD

- Status:
  - – C and Java engines complete
  - – Python engine soon
  - – OrangeFS support for OSDs

Summary

- Active storage networks
  - Improves performance of computation kernels
  - Useful in parallel file system optimizations
- Active storage for improved file system performance
- Acknowledgements: NSF CCF-0621448, CCF-093787

Communication and Protocols

- Coherence schemes
- Scalable abstractions for scientific data
- Scalable replication, relocation, failure detection, and fault tolerance
- Topology aware storage layout
- Wide area storage access protocols
- Cloud storage?
- Inter-stack communication?
- Memory hierarchy?